Audio Recording Compression

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Executive Summary

(U//~~LES~~)) Audio compression is used to reduce the storage requirements for all types of audio recordings. Compression is employed when storage space is limited. Compression is divided into two broad categories: lossy and lossless. Lossless compression maintains all of the original data. Lossy compression will discard data from the original. This data is lost forever.

(U//~~LES~~)) All audio compressions use a codec, which is a coder/decoder. Typically these are software based and vary greatly in terms of speed, sound quality, and how much memory space they can save.

(U//~~LES~~)) The chosen audio compression method is determined by the final user's preferences. If sound quality or positive verification is paramount, such as in a consensual recording scenario, a lossless or uncompressed file would be the preferable option. When file size is critical, such as in a music playback device, a lossy codec is preferable.

(U//~~LES~~)) There is a vast array of codecs available, mostly in a free format. Comparing these can be difficult for the average user. From an objective standpoint, codecs can be judged by how much the original file can be reduced or the time it takes to complete the process. Listening to the results of a codec is the true test of a codec. If the sound quality does not match the intended purpose, it should not be used.

Audio Recording Compression - Continued

(U//~~LES~~)) If possible, audio compression by law enforcement [redacted] b7E

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Defining Terms

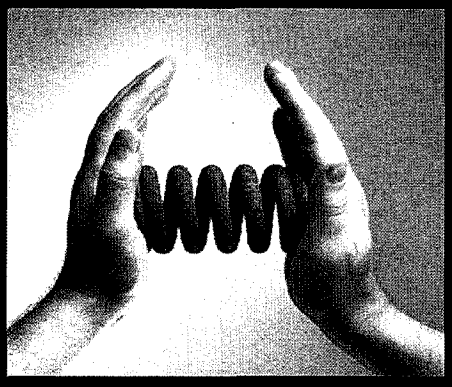
(U//~~LES~~)) Before further discussing audio compression it is beneficial to explain exactly what is meant by the term. Audio compression is employed to reduce the file sizes for any audio recording from iPods to evidentiary files.

Audio compression can also refer to dynamic range compression where extremes, such as a movie passage containing explosions, are limited to allow playback on systems with smaller ranges. Simplistically, all signals over a certain "volume" are reduced to a lower maximum level. When audio speakers produce loud distorted sounds, then their dynamic range has been exceeded.

(U//~~LES~~)) Audio data compression is all about saving memory. Audio quality is sacrificed in favor of enhanced portability or increasing the amount of time that is capable of being recorded. This is often at odds with law enforcement goals.

Audio Recording Compression - Continued

Compression Basics



(U//~~LES~~)) Compression is used to fit more or longer files into a given block of memory. This is usually done to reduce file sizes for archiving/storage. To accomplish this goal, a codec is used. A codec is a combination of coder and decoder. This is essentially an algorithm that modifies the input file to make it smaller. The key is to keep the sound as close to the original as possible.

Psychoacoustics

(U//~~LES~~)) Most codecs use what is known as psychoacoustic modeling. This is a branch of study that investigates what can be heard by the human ear under different conditions.

(U//~~LES~~)) The areas of study within psychoacoustics include: frequency cut off, threshold of hearing, and masking.

Frequency Cut Off

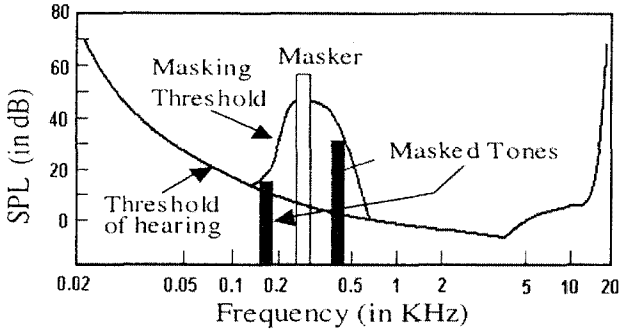
(U//~~LES~~)) The human ear is not perfect and can hear certain frequencies better than others. Sounds about 20,000 Hertz cannot be heard and can safely be discarded, reducing the memory required for storage. Some codecs discard sounds as low as 16,000 Hertz and above with only minor effects on audio quality.

Threshold of Hearing

(U//~~LES~~)) Sounds also have to be loud enough to excite the ear drum in the listener. There can be recording data that is present which would be inaudible to someone present. These sounds can also be discarded with little or no sound quality effect. However, with signal enhancement techniques, it might be possible to make the discarded data audible. This would mean that possible evidence is being deleted.

Audio Recording Compression - Continued

Masking



(U//~~LES~~)) In the diagram the signal marked as the "Masker" would overpower the sounds marked as "Masked Tones", making them inaudible. There has been a substantial amount of study done to determine what a given Masker will do to surrounding sounds. The loudness of the Masker has a great bearing on other nearby tones. More masking can be expected in proportion to the loudness of prominent sounds. An easy example to explain this is an airplane passing overhead at a low altitude. If a normal conversation is taking place, as the plane nears, communication at the previous volume becomes impossible. Talking at the same loudness in this situation will be pointless. The louder sound masks the softer sound.

(U//~~LES~~)) Also, frequency has a great deal of influence here. A Masker at one frequency might block nearby sounds out, while at another frequency, nothing would be noticed by a listener.

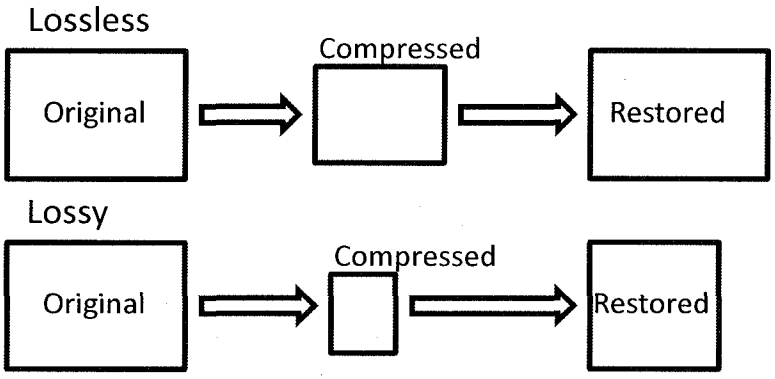
Compression Schemes

(U//~~LES~~)) Compression is divided into two broad categories: lossy and lossless. Lossless compression is similar to a zipped computer file in that all original information is retained, bit for bit. Lossy compression schemes discard data that is deemed unnecessary or redundant.

Audio Recording Compression - Continued

(U//~~LES~~)) The original recording is not completely recoverable when using any lossy method.

(U//~~LES~~)) The diagram below shows a comparison of the two methods and the resultant file sizes. Note that the lossy compressed file is smaller than lossless file. This is a primary reason that lossy files are preferred in many applications. Technically, the restored lossy file is actually the same size as the original, the smaller box here is to indicate that content is lost from the original.



(U//~~LES~~)) All audio compression uses a codec. These can be implemented in software or hardware. These codecs vary widely in their speed of processing, quality of playback, and degree of shrinking the original file size. Audio codecs are preferable to audio/video codecs when working with audio files as they achieve a greater compression percentage.

Audio Recording Compression - Continued

(U//~~LES~~)) One technical issue to be aware of is bit rate. Bit rate refers the quantity of data allocated to a given period of time. The higher the bit rate, the better the sound. However, this will also increase the file size, which in some cases, is undesirable. Bit rates are typically shown in kilobytes per second, or kbps.

(U//~~LES~~)) The audio compression scheme used is completely dependent on the intended use. [redacted] b7E

[redacted] Where file size is critical, such as in a mobile application, a lossy codec is almost always the preferred method.

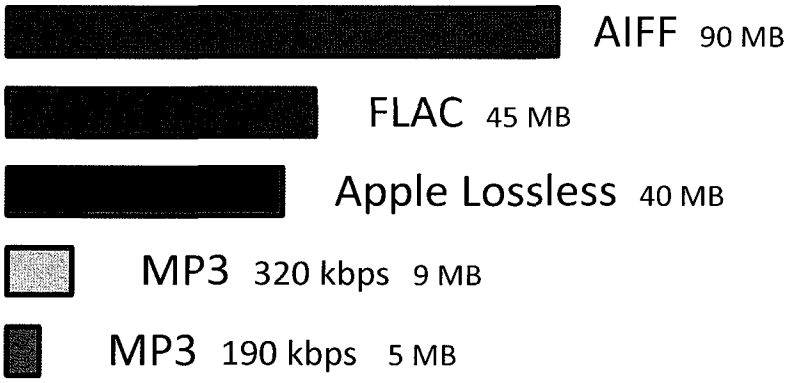
(U//~~LES~~)) The current state of art in codecs is as vast as the different uses. Objectively, these codecs can be compared in two different ways: compression ratio and coding and decoding speed. Subjectively, codecs are judged on sound quality in regards to fidelity and faithfulness to the original.

Compression Ratio

(U//~~LES~~)) Compression ratio refers to the actual amount of memory saved. The higher the compression ratio, the smaller the encoded file. Lossy codecs have much higher compression ratios. This illustration gives a comparison: (AIFF stands for audio interchange file format and is an uncompressed file format.)

Audio Recording Compression - Continued

(U//~~LES~~)) Audio File Sizes 4 minute song



(U//~~LES~~)) The above diagram shows that the memory savings for the lossy codecs is far superior to the lossless. This also gives you an idea of why they are so popular with portable devices such as the iPod.

Sound Quality

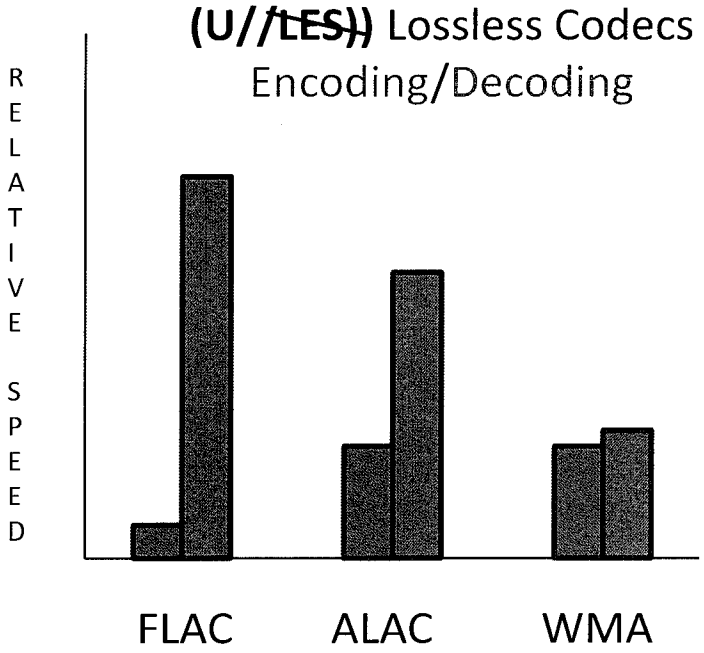
(U//~~LES~~)) Sound quality of a codec is a highly subjective topic. One listener might find a codec to sound fine while another might find it marginal. Most of the time, the major codecs do an effective job of replicating the original recording. They do not replicate high quality audio recordings and there is degradation in all lossy codecs, but they would pass a listening test from a majority of users. An exception to this is a codec employed with a very low bit rate. The bit rate is amount of information (memory) given to each second of audio.

Audio Recording Compression - Continued

(U//~~LES~~) Many codecs allow low bit rates and the resultant audio can be inferior. Using low bit rates in a law enforcement recording is highly discouraged.

Coding Speed

(U//~~LES~~) There are two different speeds for each codec: encoding and decoding. In some applications the encoding speed is more important. For instance, when ripping CDs, a faster encoding speed would enable the user to complete the compression faster. Playback decoding speeds might be important when listening to music. A user would not want to wait 5 or 6 seconds for a track to start after pushing play.



Lossy Codecs

MP3

(U//~~LES~~)) MP3 is by far the most well known and popular audio codec. This codec is used in a wide variety of devices and is the de facto standard for internet audio downloads. MP3, which stands for Moving Picture Experts Group (MPEG) Audio Layer III, is not easily characterized. MP3 has many available bit rates ranging from 32 to 320 kbps. The size and quality of the files is directly correlated to bit rate. At 320 kbps, the sound quality is quite good, while at 32 kbps it is very poor as you might imagine. Coding speed is also dependent on bit rate.

Dolby AC-3

(U//~~LES~~)) Dolby Digital, which you probably know from going to theatres, was first developed for cinemas to convert the 35 mm film print audio to Dolby Digital. AC-3 has 5 channels plus a limited frequency subwoofer channel. The bit rate is fixed at 320 kbits/sec and audio quality is quite good.

Audio Recording Compression - Continued

Windows Media Audio (WMA)

(U//~~LES~~)) WMA was designed in an attempt to compete with MP3 and RealAudio. RealAudio is the popular streaming software which uses many different codecs. It is standard in any Windows software and delivers acceptable audio. There are four different WMA codecs including WMA Pro, which is the latest iteration. The speed of the codec is dependent on the version used.

MPEG-4

MPEG-4

(U//~~LES~~)) WPEG-4 is a method of defining how to compress audio and video. There are numerous standards documents detailing the specifics. MEPG-4 is used by DirecTV satellite service. There are different versions of MPEG-4, but they are all considered to give average to excellent audio and video. Decoding speed is determined by settings chosen by the user.

Lossless Codecs

Waveform Audio File Format (WAV)

(U//~~LES~~)) WAV compression is a Microsoft and IBM codec. These files are large and infrequently used for file sharing. This codec is used widely where file space and time of compression are not a concern. These files have a maximum size of 4 Gbytes which is about 6.8 hours of high quality stereo audio.

Audio Recording Compression - Continued

Apple Lossless Audio Codec (ALAC) Apple Lossless

(U//~~LES~~)) Apple developed this lossless codec in 2004 and kept it proprietary until 2011. This codec achieves a 40-60% compression ratio. Compared o other codecs, it is less power hungry when decoding. ALAC also, unlike WAV files, allows for metadata such as dates and pictures to be added.

Free Lossless Audio Codec (FLAC) flac

(U//~~LES~~)) This codec is very popular for storing compact disks to a hard drive. This compression is quite effective and can achieve nearly 40-50% compression ratios. FLAC has one of the fastest decoding speeds which is ideal for music playback. It also allows metadata.

Meridian Lossless Packing (MLP) MLP Meridian Lossless

(U//~~LES~~)) This proprietary codec is very flexible and allows up to 8 channels of audio. It is used in DVD-Audio and Dolby TrueHD which is a Blu-ray audio format. The compression ratio is typically 33%.

Audio Recording Compression - Continued

Law Enforcement Impact

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